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Hydrogen economy: Globally, domestically and at

Óbuda University

Emőke IMRE – István SZÉN

The industrial revolution changed the all relations of the previous energy use.

It started the increasing exploitation of the fossil fuel reserves.

By combustion of the fossil fuels heat and burning gases are originated. The burning gases /CO_2, CO, SO_2, NO_x/ are emitted into the environment. It means that the MAN became capable to exert damaging influence for the natural environment. It was realized, suddenly with dismay, in the middle of the 20th century only.

The energy need of the industrialized /developed/ countries increased quickly and, the total energy consumption of the World became also the function of the industrial development, beside the population.

At the same time, in the developing countries, the energy consumption remained almost the same, without any increase and, at present, the basic energy supply of about 2 billion people is not ensured.

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Tasks at the system level in the protection of the environment

- Energy security: reduce dependence on fossil energy sources
- Global warming, keep under control!
- Reduce carbon-dioxide emissions!
- Take advantage of the potential inherent in renewable energy sources!
- Educate the new generation on „clean technologies”
- Thinking! How can I make our lives better?

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Megatrends and global challenges

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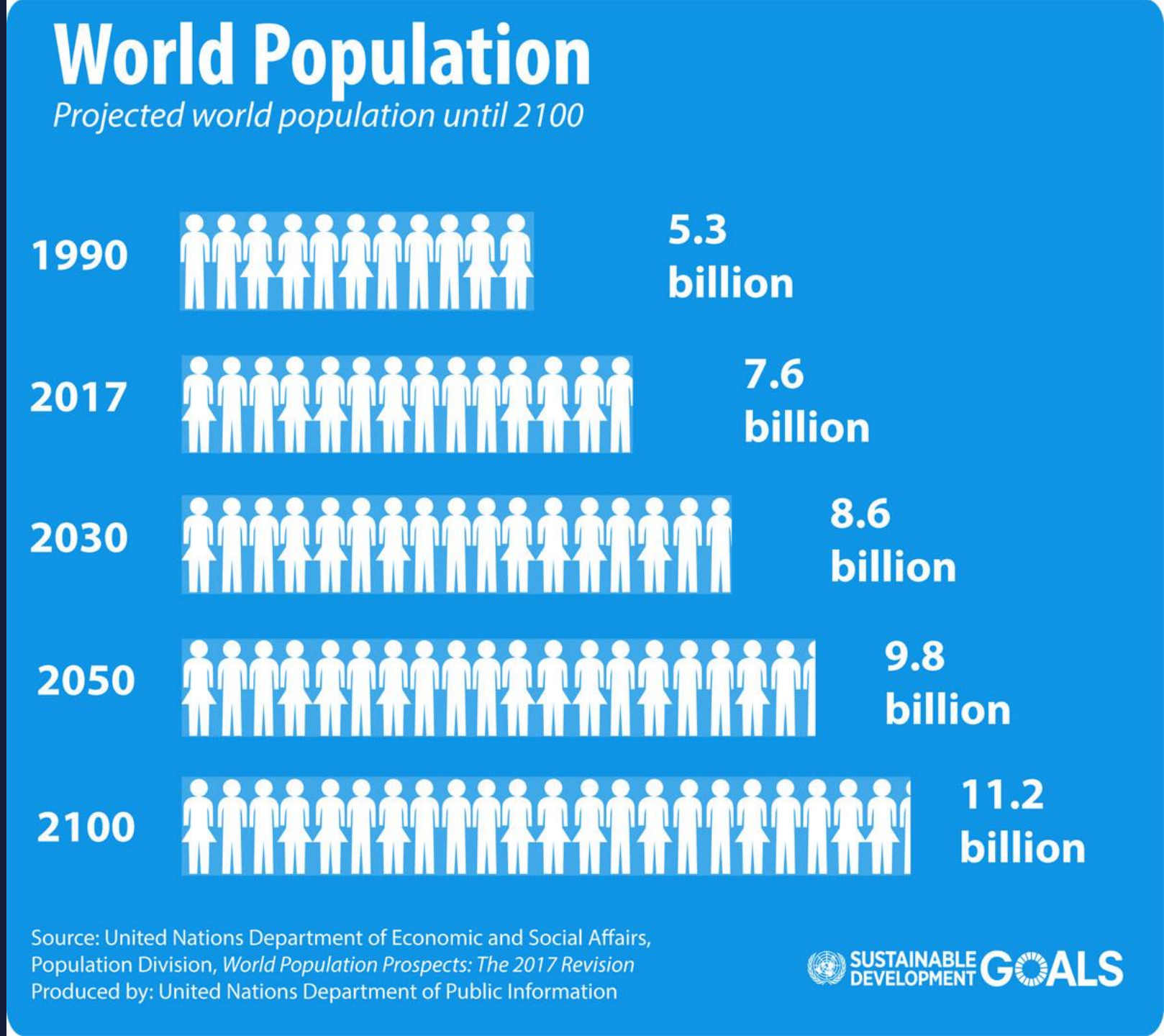
World Population

Based on surveys, the world's population will approach

10 billion by 2050



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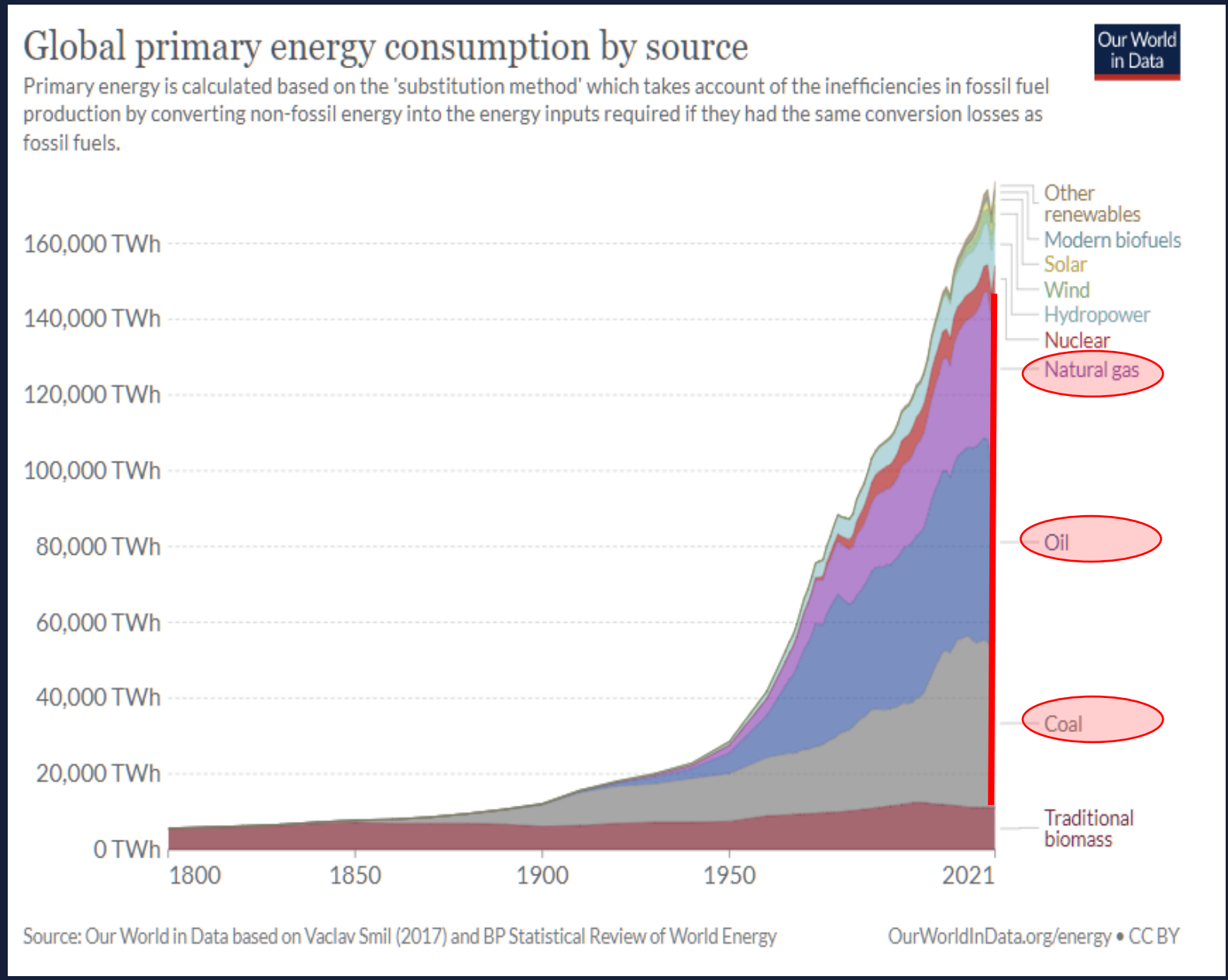
Global Primary Energy Consumption

Even today, there is a very strong dependence on fossil energy sources!



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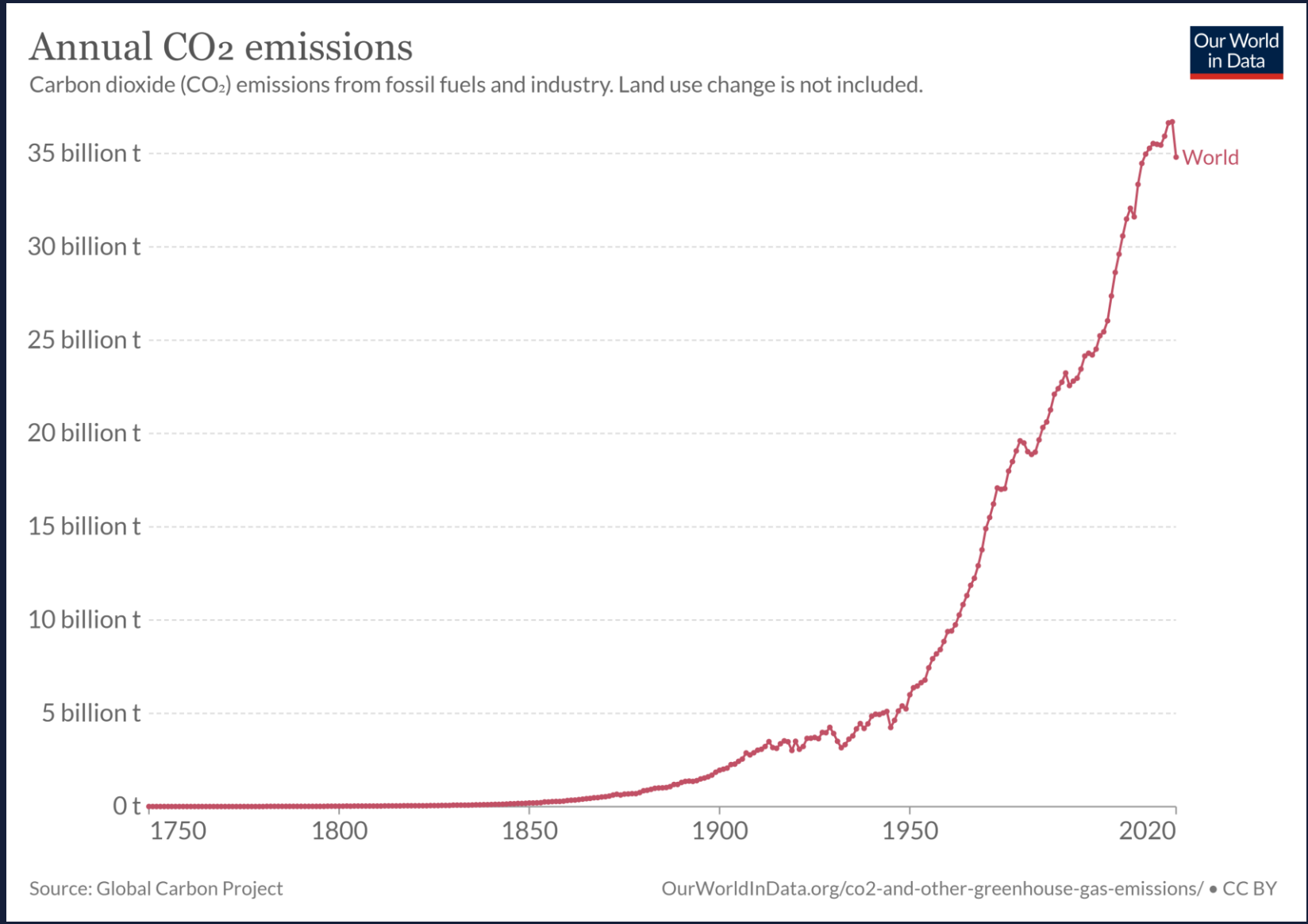
CO2 - emission

There has never been so much CO2 in the atmosphere since earth became a habitable planet for humans



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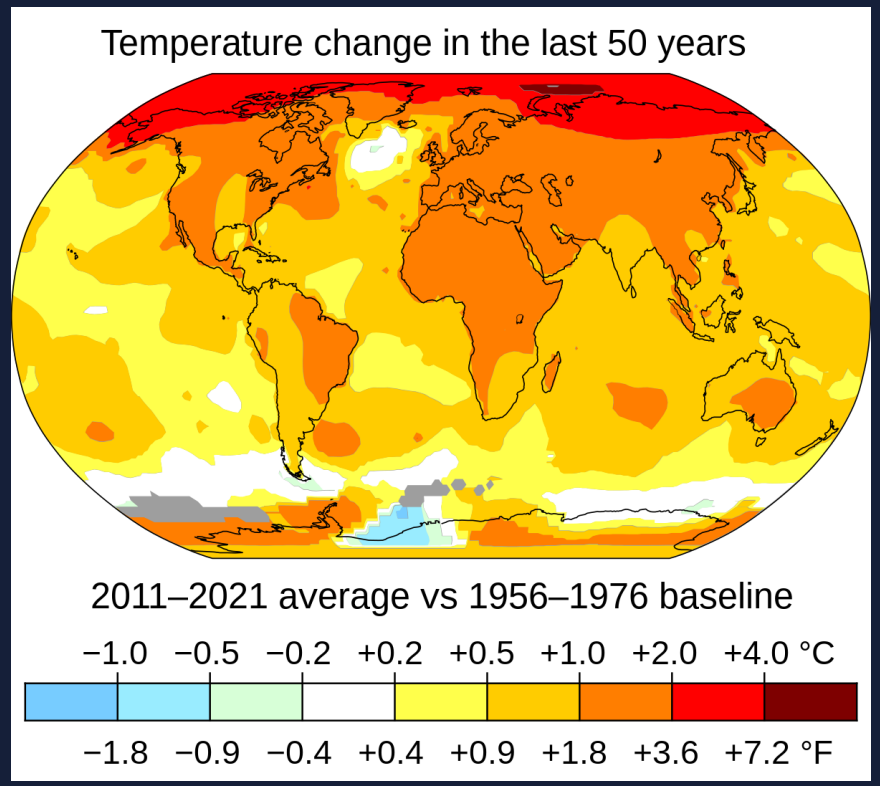
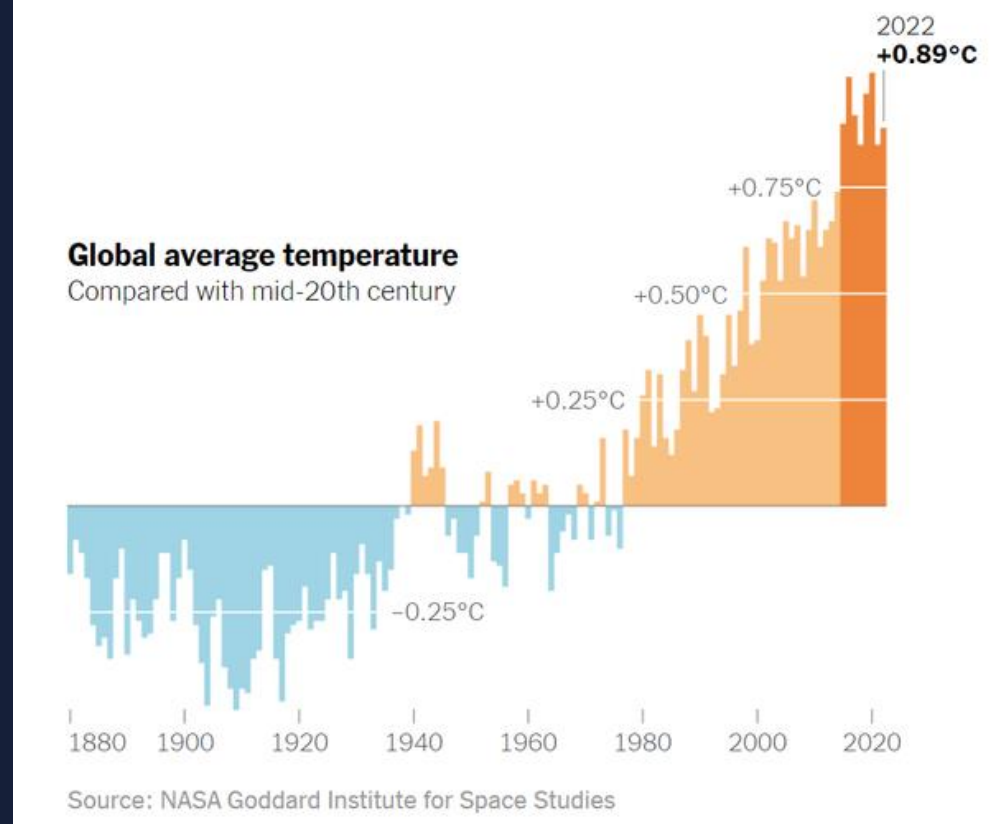
Global temperatures are rising, weather is becoming more extreme





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Geopolitical tensions

Russia – Ukraine → EU

USA – CHINA → World ?

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Action must be taken!

Let's find the solution!

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The goal of European Union

The European climate law makes reaching the EU's climate goal of reducing EU emissions by at least 55% by 2030 a legal obligation. EU countries are working on new legislation to achieve this goal and make the EU climate-neutral by 2050.

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The Hungarian government publishes the domestic hydrogen strategy (2021.06.15.)

Source in english:

https://kormany.hu/dokumentumtar/magyarorszag-nemzeti-hidrogenstrategiaja

VISION OF THE HYDROGEN STRATEGY

We are developing potent competencies with regard to the key elements of the hydrogen value chain, which, supplemented through targeted RDI and economic development activities, will serve to promote the shift towards a carbon-free society and to maintain the competitiveness of the Hungarian economy.

PRIORITY OBJECTIVES - 2030

Production of large volumes low-carbon and decentralized carbon-free hydrogen

Establishing the conditions necessary to produce low-carbon and carbon-free hydrogen that is in compliance with user requirements and is competitively priced.

- **20 thousand tons / year low-carbon hydrogen**
  +
- **16 thousand tons / year "green"* and other carbon-free hydrogen**
- **240 MW electrolyser capacity****

Decarbonisation of industrial consumption, partly with hydrogen

At first, predominantly low-carbon hydrogen will be used to make the industrial processes and product use "more green", with a shift to carbon-free hydrogen usage on the longer term.

- **20 thousand tons / year low-carbon hydrogen**
  +
- **4 thousand tons / year "green"* and other carbon-free hydrogen**
- **avoiding the emission of 95 thousand tons of CO_2**

Green transport

Accelerating the transition to clean modes of transportation by a gradual transition from gas oil usage to clean alternatives. Within this framework, on the 2030 timeline, hydrogen may become a realistic alternative primarily in heavy-duty vehicle traffic.

- **10 thousand tons / year "green"* and other carbon-free hydrogen**
- **20 hydrogen refuelling stations / 40 refuelling points**
- **4.8 thousand HFC vehicle**
- **avoiding the emission of 130 thousand tons of CO_2**

Electricity and (natural) gas support infrastructure

Building sector integration ability - primarily seasonal energy storage ability - by utilising intersectoral synergy, establishing infrastructure that will enable the transition to carbon neutrality, and reconstructing existing infrastructure.

- **60 MW average cut-off capacity**
- **min. 2% per year volume blending ratio in the natural gas system (where appropriate)**

SUPPORT OBJECTIVES

Taking advantage of industrial and economic development opportunities

Enhancing the activities at the intersection of industrial trends and Hungary's domestic strengths in order to promote competitiveness and stimulate domestic penetration.

Horizontal conditionality: establishing a stimulating operational environment

- Establishment of comprehensive regulatory and operational frameworks,
- promoting partnership and international cooperation.

RDI and education to promote the success of hydrogen during the transition

- It is essential for the implementation of strategic objectives to establish a system of scientific, technological and horizontal competencies that can serve as a foundation for the domestic use and development of new technologies and for demonstrating the legitimacy of such technologies on the domestic market.

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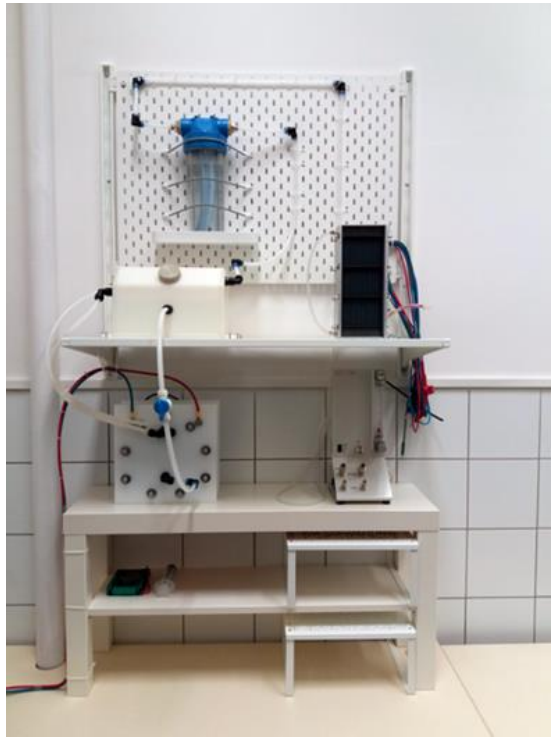
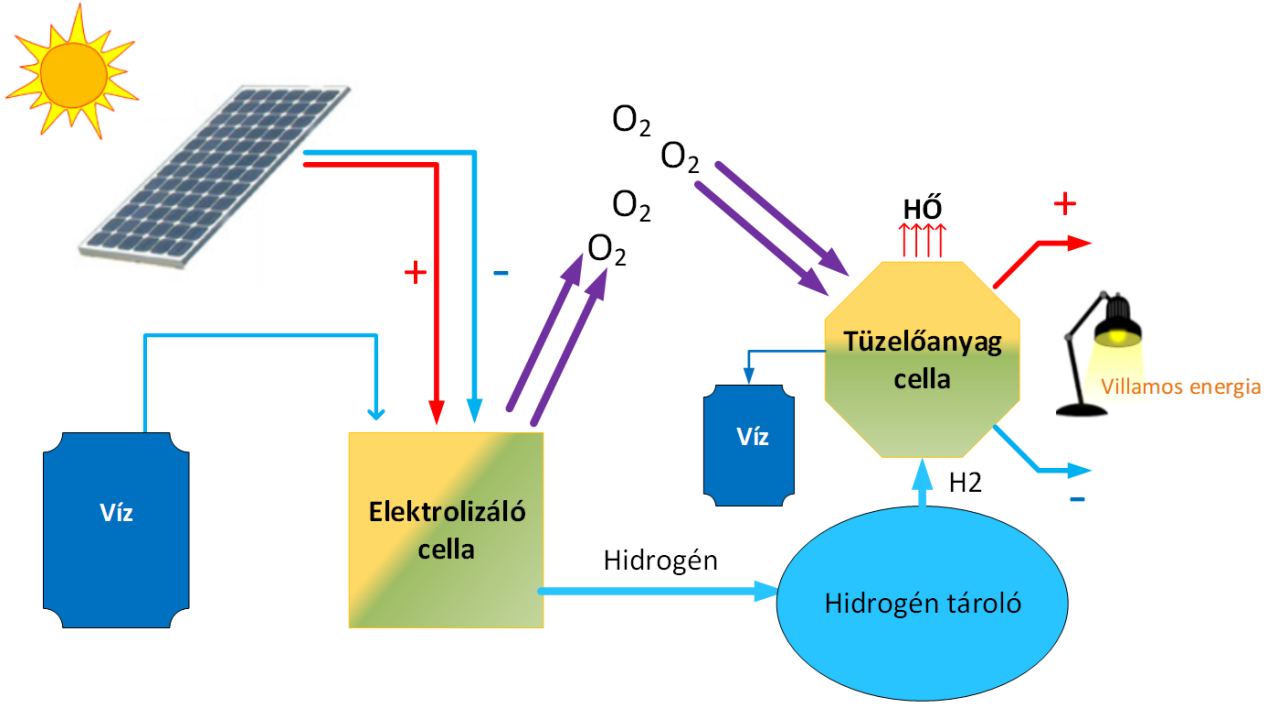
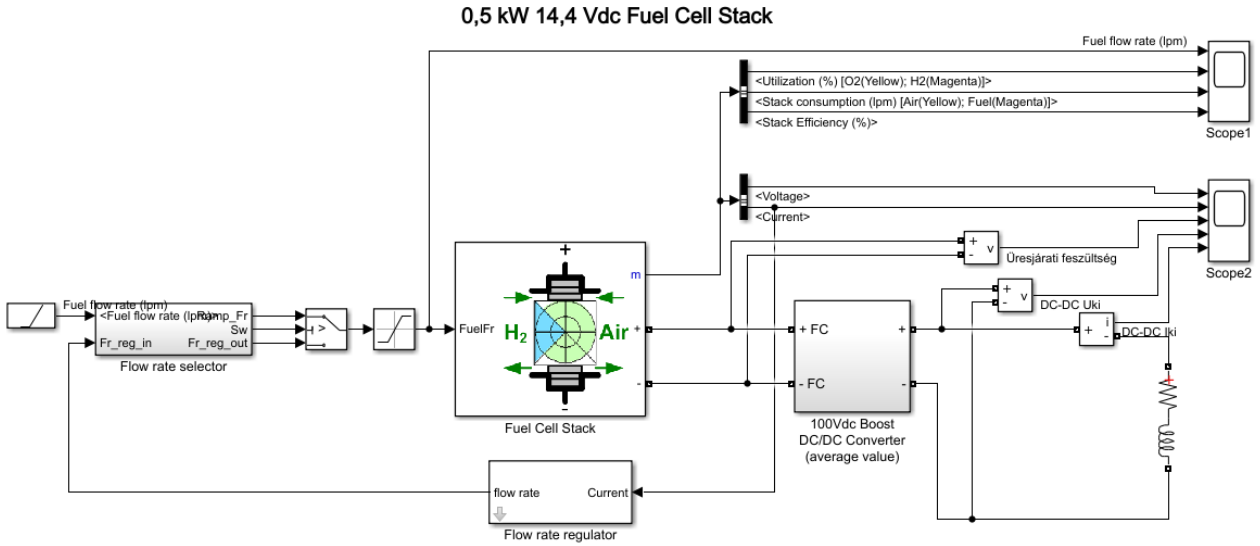
The **Óbuda University** already took the **first steps in 2017**, in the field of **hydrogen research**.







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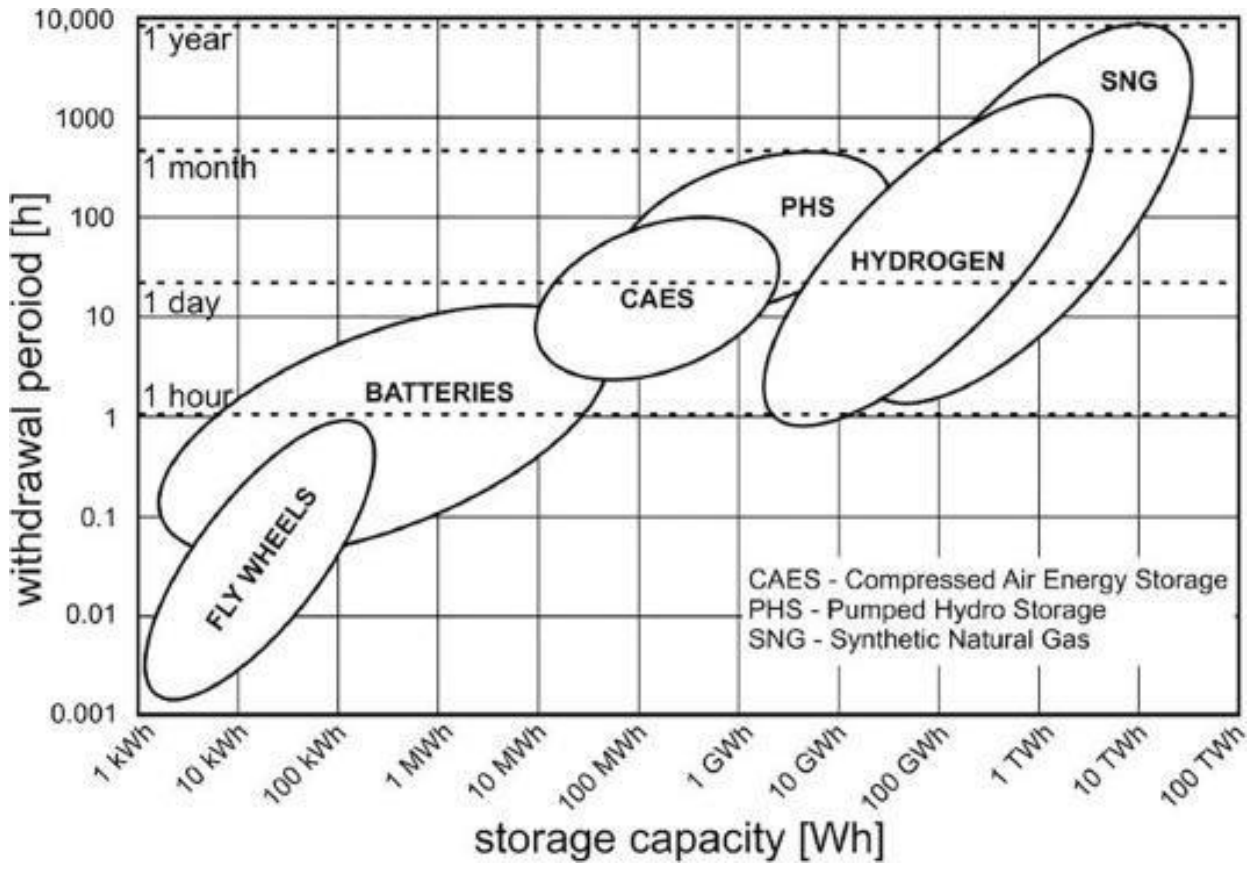
But why to store energy in Hydrogen?



theory

The surplus electrical energy can be used for producing H2 by water electrolysis, or some kind of gas components by dissociation. The stored energy can be gained back by using the **hydrogen as fuel** or, by realizing the synthesis of the gas components.

The gas and liquid biofuels are carbohydrates and contains hydrogen. The hydrogen can be used in direct process for electricity generation in fuel cells.

theory

Hydrogen is an environmentally friendly fuel which can be produced by electrolysis of water /powered by solar, wind or hydro-electricity/, by gasification of biomass and by thermal water-gas shift reaction.

Hydrogen can easily be stored and transported.
When hydrogen is burned, the product is, water /H20/ and the heat released is 242 kJ/mol. During the combustion NOx is originating, the quantity of it depends on the burning temperature and the burning system. The NOx emission can be reduced to negligible levels.

Hydrogen can be stored as compressed gas on high pressure /16...68 MPa/ in steel or aluminium tanks, and by absorption in metal-hydrides on high pressure. The absorbed hydrogen can be released by heat transfer.
Strongly cooled /under 18°K temperature/ hydrogen is of liquid state and can be stored in tanks and transported in pipe-lines.

By the use of hydrogen, electricity can be generated directly in fuel-cells.

theory

Hydrogen can be produced by water electrolysis, when oxygen is the by-product. The renewable electricity is generated from various renewable energy carriers /by wind electric, hydro-power, solar thermal electric, solar photovoltaic electric systems/.

An environmentally clean and law cost new method has been elaborated for the large-scale hydrogen production by Reed Jensen /Los Alamos Labour, USA.

Hydrogen production using indirect solar energy

The large hydrogen production systems need water in large quantities therefore, it is reasonable their establishment near the sources of *hydropower.*

Hydrogen can also be produced by thermochemical *gasification of biomass* feedstocks. The feedstock is introduced into a gasifier at high temperature, where it breaks down to form a gas /mainly of H2, CO and CH4/. To this gas-mixture steam is added and. the final mixture consists mainly H2 and CO2. In a separator CO2 can be removed.

By gasification, fermentation and by other thermal and biological processing methods **ethanol and methanol** can be produced from sugar, cellulose containing biomass and from other hydrocarbons /natural gas, petroleum naphthas/. Ethanol and methanol are also usable for H2 production.

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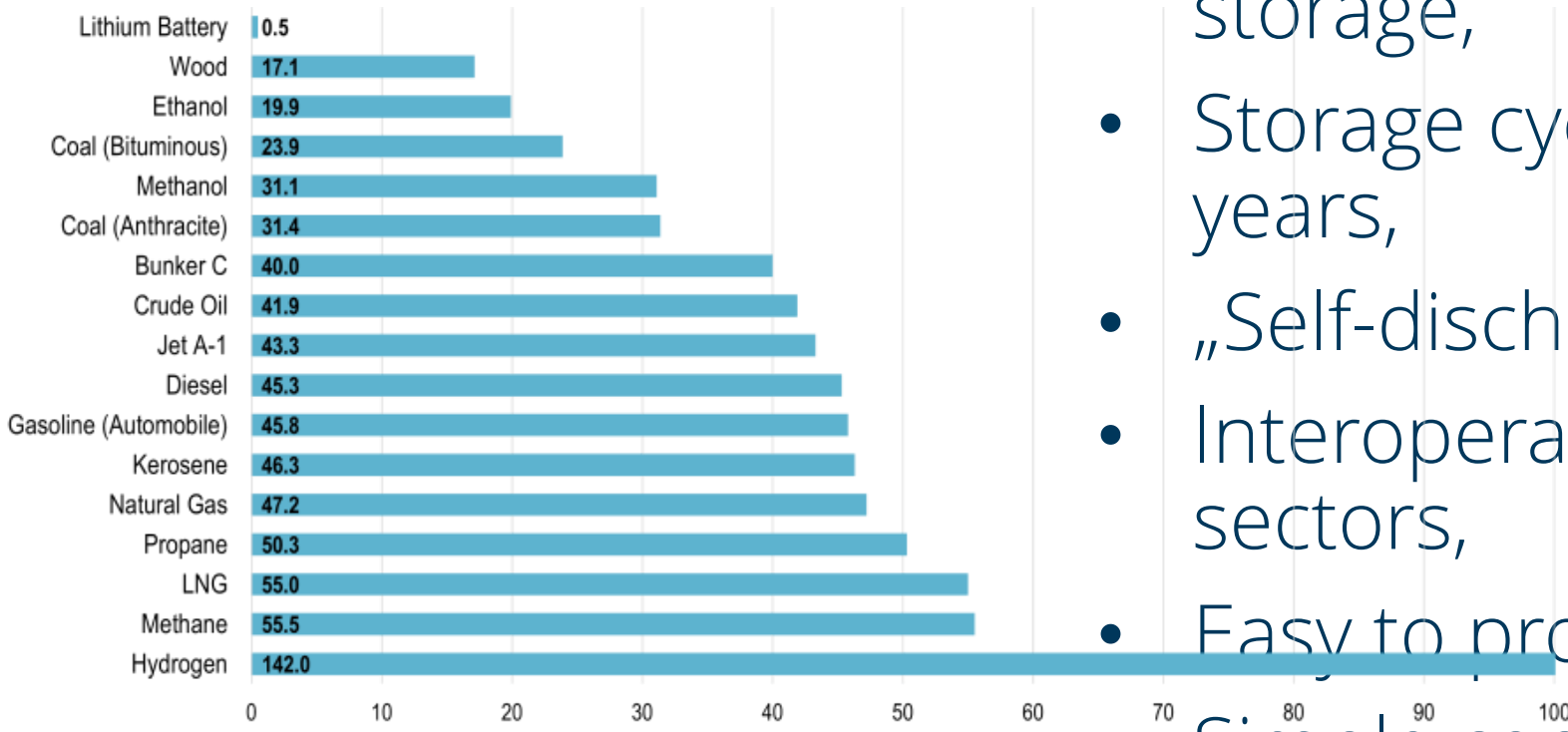

Energy Density in MJ/kg

- Large quantity CO_2- free energy storage,
- Storage cycles measured in years,
- „Self-discharge" is negligible,
- Interoperability between energy sectors,
- Easy to produce,
- Simple conversion, simple use

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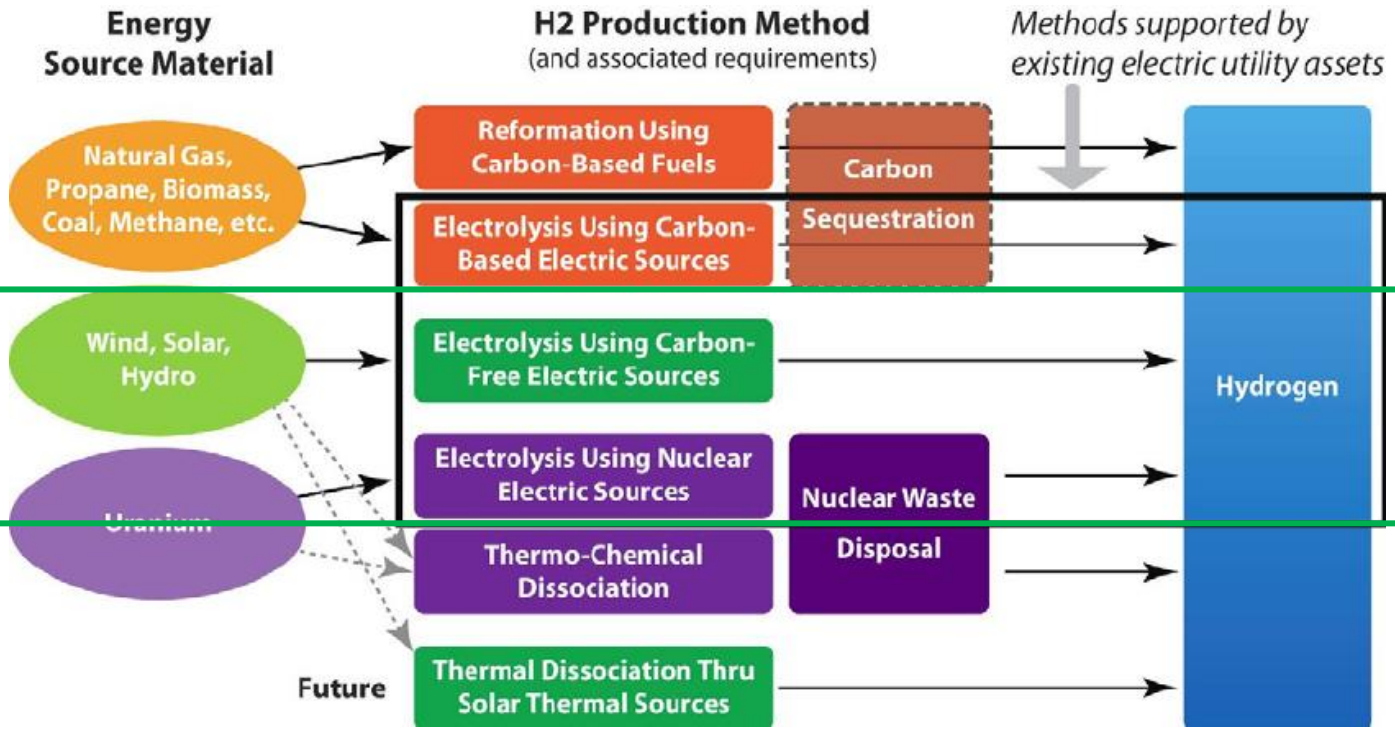
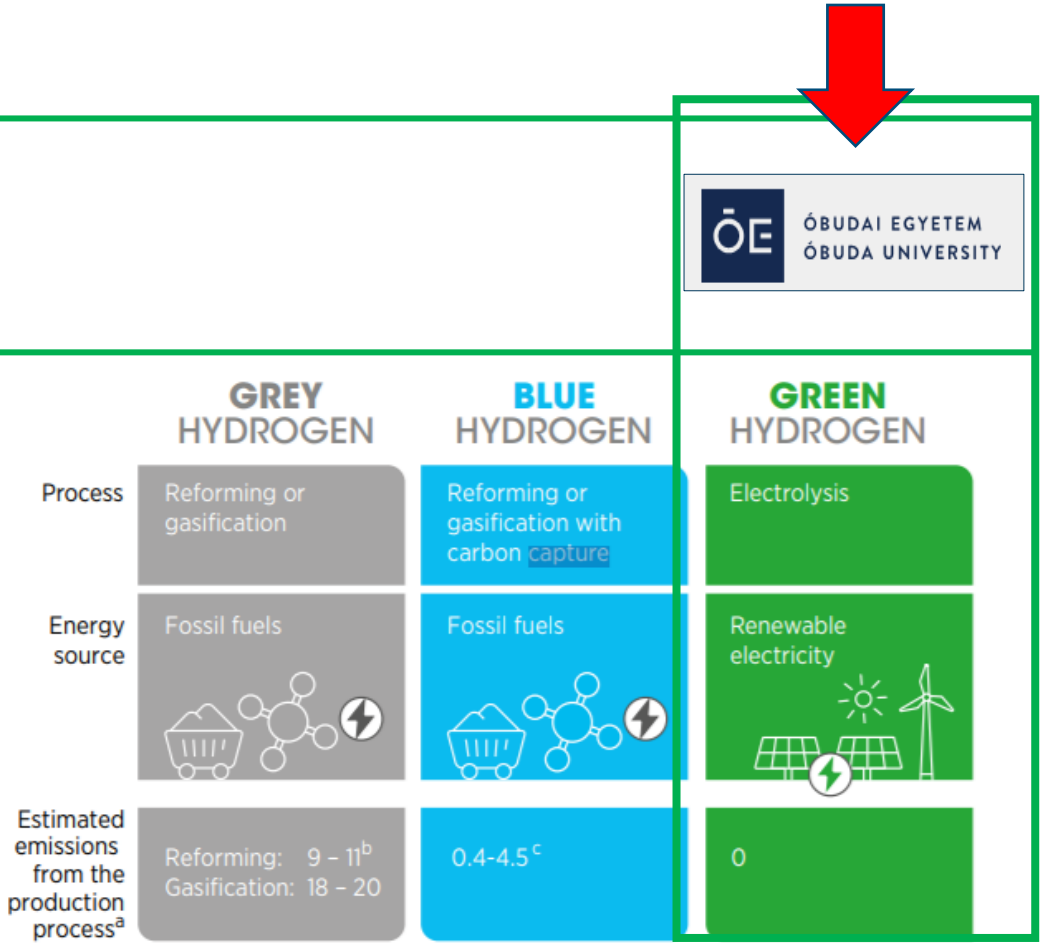
Hydrogen production and **Óbuda University** research projectes





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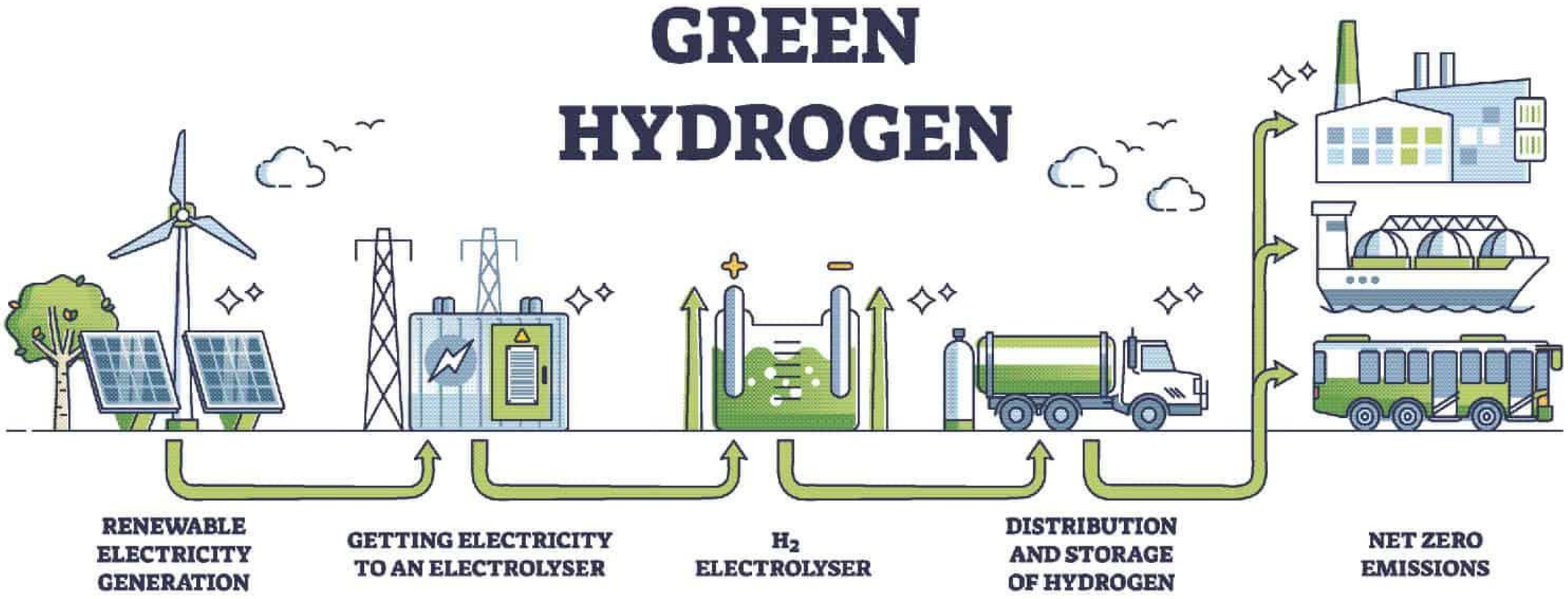
Commitment to clean technologies



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A leap of magnitude: out of the laboratory → entering the industrial scale

Our industrial partners

- Bükkábrány Energy Park
- Hungarian Electricity System Operator
- Hungarian State Railway
- Budapest Public Transport
- Domestic bus companies
- Hungarian Hydrogen and Fuel Cell Association
- Hungarian Hydrogen

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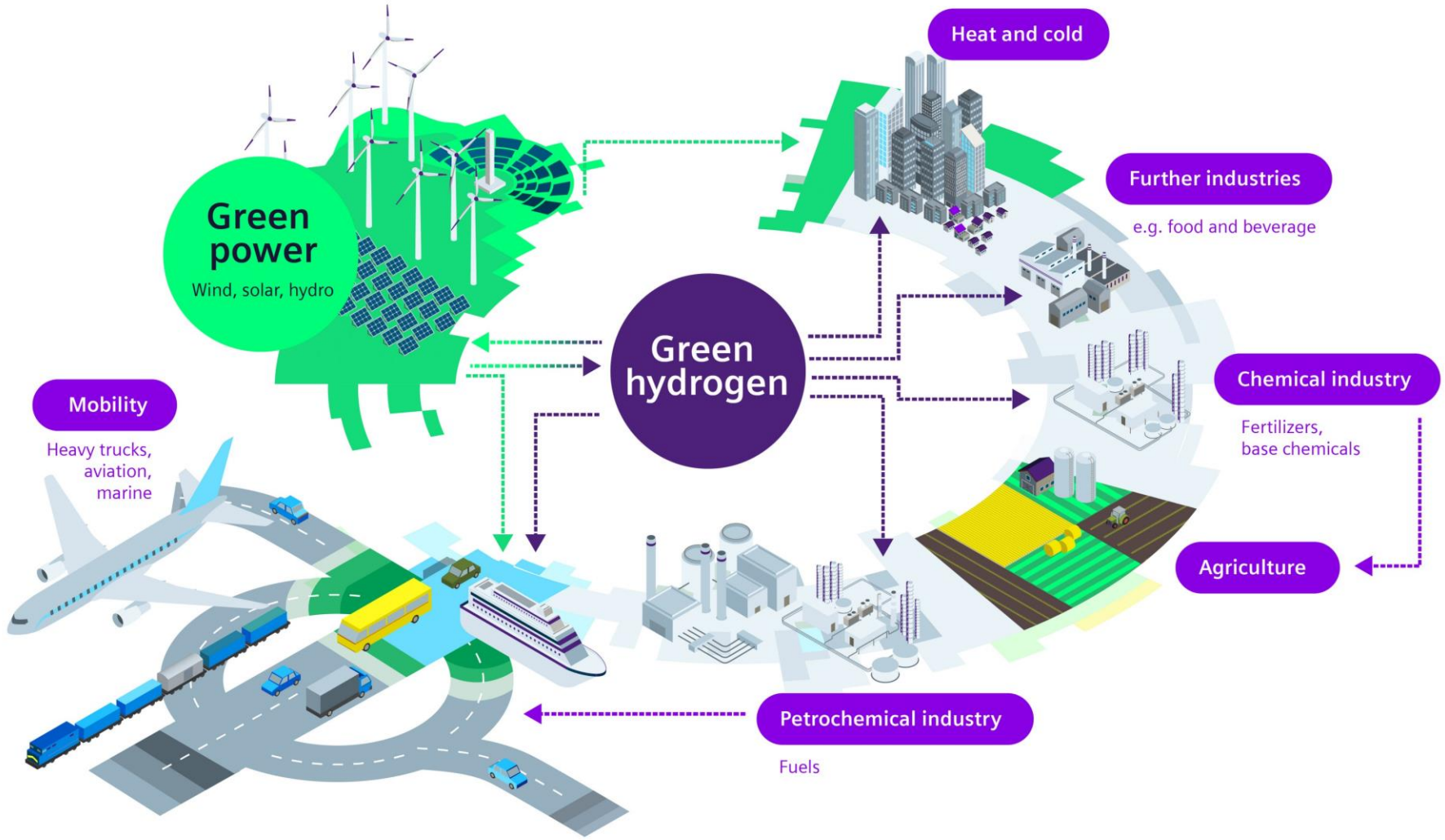
The potential of hydrogen



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The potential of hydrogen - Vehicles

The potential of hydrogen - Heavy industry → CO_2 reduction

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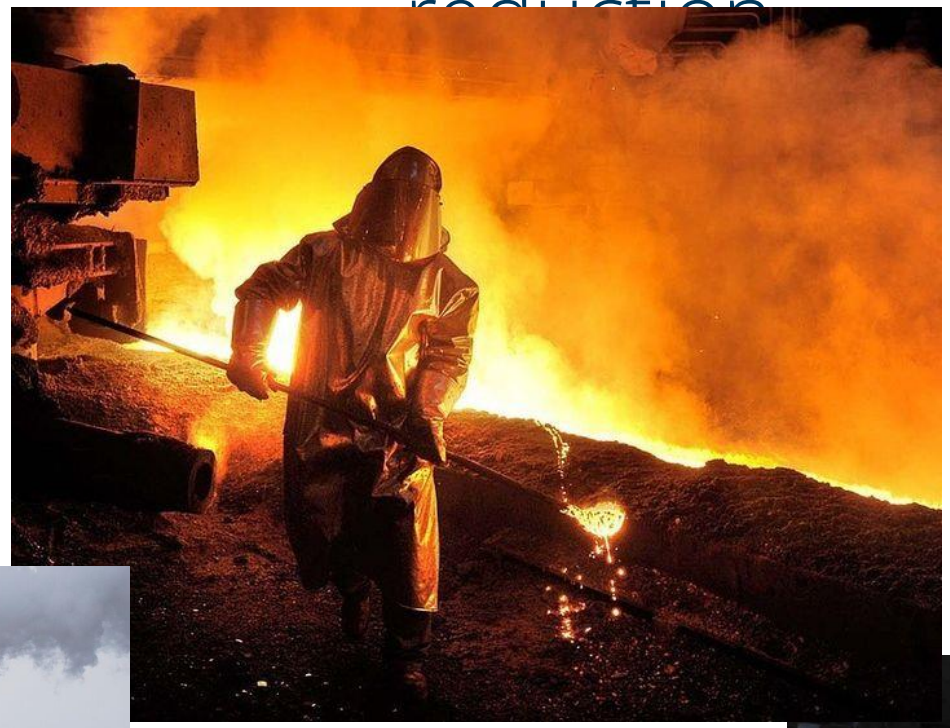
- Glass production
- Petroleum Refining
- Cement production
- Metallurgy



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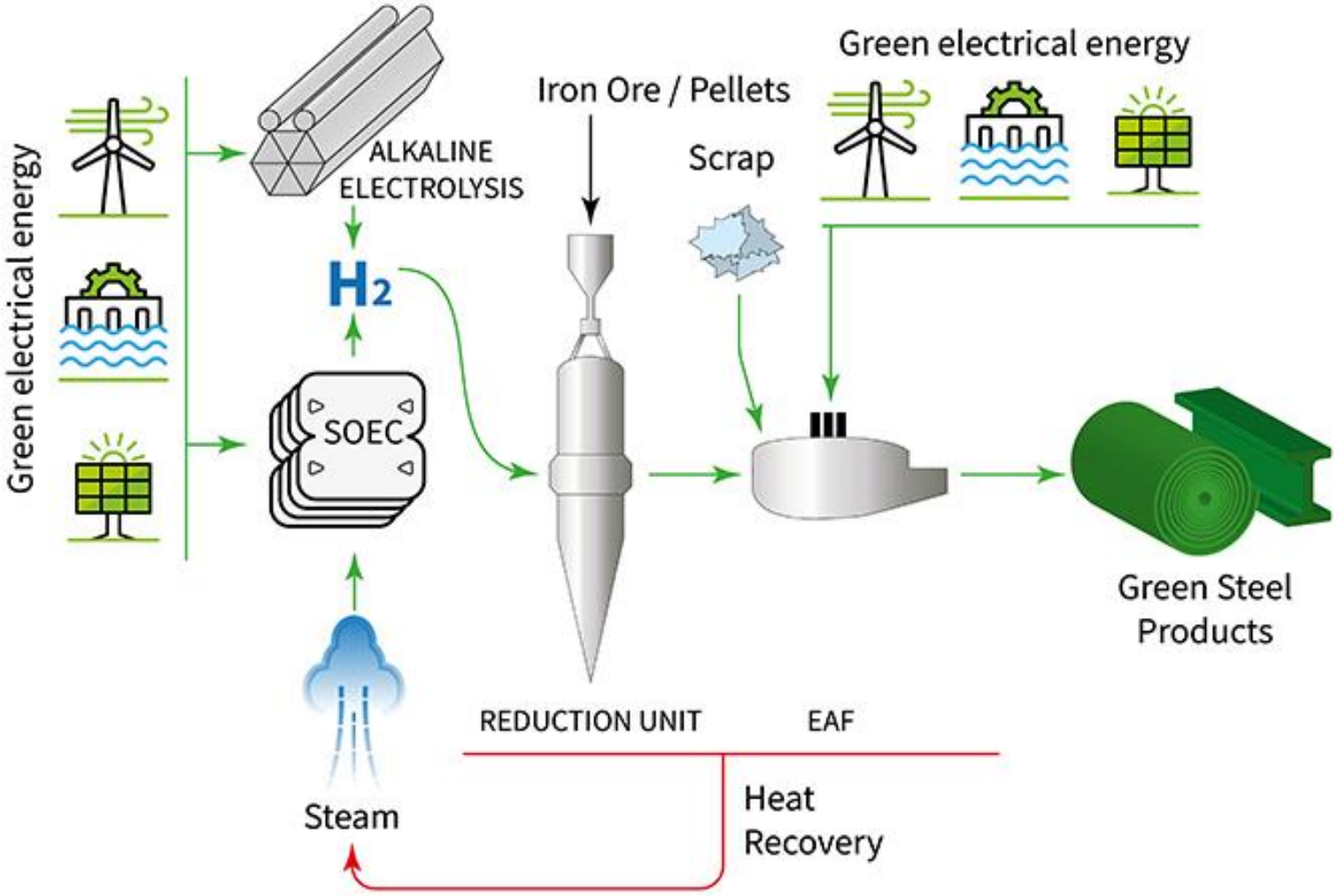
Just one example from heavy industry
Green Energy → Green Steel



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Our ongoing research

- Green hydrogen production - in partnership with Bükkábrány Energy Park
- PV-park energy management - in partnership with Bükkábrány Energy Park
- System-level electricity regulation
- Emergency power supply
- Electrochemical energy storage - in partnership with Samsung
- Environmentally friendly transport
  - Freight train
  - Passenger train
  - Bus

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Óbuda University answers to professional trainings

- **University-level** (electrical engineer, mechanical engineer, civil engineer, environmental engineer, economics) cooperation in supported projects
- **Electrical engineering →** BSc and MSc (Optional subjects, independent projects, theses, scientific student conferences)
- **Hydrogen mobility engineer** (Postgraduate, professional engineer training)
- **Hydrogen industrial engineer** (Postgraduate, professional engineer training))

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Our philosophy

The Óbuda University voted for sustainable development.

During the development of our research portfolio and the development of our educational program, we strive to that the invested energy serves our society and environment.

We believe in a clean and livable future!

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Thank you for your kind attention.

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